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INTERIM REPORT NO. 4
Period Covered: August 15, 1961 to July 31, 1962
LOW TEMPERATURE BA-2270/U-XLT-I BATTERIES
Signal Corps Contract No. DA-36-039-SC-78144
File No. 0334-PM-58-91-91 (3831)
Department of the Army Task No. 3A99-09-002-02
Placed by: United States Army Signal Research and Development Laboratory, Fort Monmouth, N.J.
RAY-O-VAC COMPANY
Division of the Electric Storage Battery Company
Madison, Wisconsin

AD ______________ Accession No. ______________

RAY-O-VAC COMPANY, Madison, Wisconsin
Division of The Electric Storage Battery
Company, Philadelphia, Pennsylvania

LOW TEMPERATURE BA-2270/U-XLT-1 BATTERIES
J. W. Paulson
Interim Report No. 4, July 31, 1962
12 pages, 2 tables
Contract No. DA-36-039-SC-78144
DA TASK NO. 3A99-09-002-02
UNCLASSIFIED REPORT

Twenty-four months delayed performance test results are reported for in-plant testing of production batteries at −40° F, −20° F and 70° F. The lithium chloride electrolyte was employed in combination with a separator designated as CP-2 paper. Batteries were stored at both 35° F and 70° F.

UNCLASSIFIED

1. Batteries, low temperature.
2. LeClanche system.

AD ______________ Accession No. ______________

RAY-O-VAC COMPANY, Madison, Wisconsin
Division of The Electric Storage Battery
Company, Philadelphia, Pennsylvania

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UNCLASSIFIED

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LOW TEMPERATURE BA-2270/U-XLT-I BATTERIES

Interim Report No. 4

Period Covered: August 15, 1961 to July 31, 1962

Object: To construct 500 batteries of the improved flat cell BA-2270/U type for initial and delayed testing by both the Signal Corps and the contractor.

Signal Corps Contract No. DA-36-039-SC-78144
File No. 0334-PM-58-91-91 (3831)

Department of the Army Task No. 3A99-09-002-02

Report Prepared by:

J. W. Paulson

J. W. Paulson

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PURPOSE

The purpose of this work was to construct 500 BA-2270/U batteries of the flat cell type for initial and delayed service testing, such testing to be conducted by both the Signal Corps and the contractor. This production was preceded by the construction of 50 preproduction batteries for 0 and 3 month testing before construction of the 500 was begun. The basic design of this battery has been developed under Signal Corps Contract No. DA-36-039-SC-73179, "Study of Low Temperature Batteries".

ABSTRACT

Twenty-four months delayed testing results are reported for the LiCl:CP-2 low temperature LeClanche system. Discharge tests were run at 70° F., -20° F. and -40° F., after 24 months storage at both 70° F. and 35° F. Problems caused by electrolyte leakage, preferential zinc corrosion, etc., are discussed along with their effect on performance.

CONFERENCES

(I) Subject: General discussion of BA-2270/U performance.

Organizations Represented: U. S. Army Signal Research and Development Laboratory. (Mr. James Settembre)

Ray-O-Vac Company (Messrs. Philip Albert and John Paulson)

Place: Ray-O-Vac Research Laboratory Madison, Wisconsin

Date: February 1, 1962

Conclusions: Continue with original test schedule.

FACTUAL DATA

EQUIPMENT

Low Temperature Chambers

The low temperature chambers used under Signal Corps Contract No. DA-36-039-SC-73179 were transferred to this contract and used in testing batteries at -20° F. and -40° F.

Meters

Standard commercial voltmeters and ammeters were used for routine measurements.

Heat Sealer

A 24" bar heat sealer was purchased from the Vertrod Corporation, Brooklyn, New York for use in making lengthwise seals on multiple flat cell strips.

Additional heat sealers for between-cell sealing and sealing of conductive sheeting to the outer vinyl envelope were designed and constructed by the contractor.

Mix Extruder

During the early stages of battery construction under this contract, mix cakes for the B_2 section were obtained by extrusion of wet mix into a 14 mesh glass filament cloth at a thickness of 23 mils. A device for performing this operation was designed and constructed by the contractor.

Tamping Machine Tooling

Special molds and plungers were designed and constructed for tamping mix cakes on a Hasse tamping machine. The action of this tamper is like that of a Stokes pelleting machine. Excellent mix cake formation is obtained with no excessive "working" of the wet mix feed. Mix cake thickness as low as 33 mils is possible with this tamper and it was eventually used in tamping cakes for all four of the battery sections (A, B_1, B_2 and C).

Target and Leakage Tester

A special targeting control panel was designed and constructed which enabled a more rapid targeting of batteries. A standard BA-270 plug was inserted into the battery and all section voltages and amperages were then obtained by the selection of a series of switches. Undesirable current paths between some of the battery sections were found to occur occasionally. This was usually due to leakage of electrolyte from the battery bridging between sections. Neon lamps and suitable circuitry, including switches and a potentiometer, were incorporated in this target tester for indicating visually the presence of such current paths and their location. Where such defects occurred, the battery was repaired if possible or rejected.

CONSTRUCTION PROCEDURE

Details on battery specifications and procedures will be presented in the final report for this project. However, some general descriptive comments are presented herein. Where necessary, further detailed comments will be made to clarify discussion.

Construction normally proceded at the rate of 25-35 BA-2270/U batteries per week. This rate steadily increased to the latter figure during the latter stages of construction under this contract. The major construction problem was that of obtaining a heat seal which would not fail after the battery was assembled.

Batteries were numbered and coded according to the first or second half of the month in which they were constructed. For example, code 12259 would apply to batteries made during the second half of December, 1959; while 01160 would apply to batteries made during the first half of January, 1960. After stacking the various sections (A, B_1 and B_2) and banding by means of a steel band into a complete unit, the battery was targeted immediately. At 1 week the battery was again targeted and any defective sections replaced; the battery wax dipped and placed in the outer nest. The batteries were given a third targeting at 2 weeks and accepted or rejected on that basis. Acceptance values for voltage and amperage are given in Table I.

ELECTROLYTE AND MIX FORMULAE

Both lithium chloride and lithium bromide types of electrolyte solutions were included under this contract for the purpose of obtaining further comparative data on their performance. Their compositions are given in Table I.

Both MB-1 and CP-2 separator papers were employed with each electrolyte solution in the preproduction run. Results indicated no significant difference between papers after 3 months. However, the use of CP-2 paper with the bromide electrolyte is advisable. Hence, CP-2 paper was used entirely in the production run. Of the 500 production run batteries, 400 employed the LiCl:CP-2 electrolyte:separator combination and 100 used the LiBr:CP-2 combination. This latter group of 100 was requested by the Signal Corps for testing in order to obtain additional data for comparing the two systems. The formal distribution of production run batteries was as follows:

Formula Employed	To Signal Corps	In-Plant Testing
LiCl:CP-2	90	310
LiBr:CP-2	100	0

As indicated, the ratio of 20:1 MnO_2:carbon black was employed over the entire course of battery construction. Previous work (ref. - Contract No. DA-36-039-SC-73179) had indicated that the best performance was obtained with this ratio. The electrolyte content of the mix cakes was held within the range of .25 to .30cc/gm. dry mix. Higher electrolyte contents were beneficial to performance but added greatly to construction problems, particularly in heat sealing.

PERFORMANCE OF PRODUCTION BATTERIES, 24 MONTHS DELAYED

Results of in-plant testing of production run batteries is given in Table II.

Because of the high percentage of failures at both storage temperatures (35° F. and 70° F.) and the high variation in performance, no conclusions can be drawn on the effect of storage temperature on delayed performance.

Examination of batteries showed the A-section failure or low performance was due to preferential corrosion of the zinc anode around the solder joint which bonds the zinc paralleling strip to the zinc anode. This corrosion resulted in loss of some of the cells in the section and subsequent low performance.

Where B-section performance was low, one or more cells in the stack had undergone electrolyte leakage through pinholes in the conductive film. This caused the aluminum foil backing (on the conductive sheeting) to dissolve anodically, resulting in poor intercell contact at these points. Usually 1 to 3 cells were effected in this manner in low performing B-sections with the aluminum foil being virtually all dissolved away.

Another cause of battery failure was leakage of electrolyte through defective heat seals (no seal or overheated and pinholes seal) and corrosion of lead wire connections at the stack.

Examination revealed that batteries or sections which gave good performance were generally free of the above defects.

C-section performance was satisfactory, the open circuit voltages ranging from about 4.6 to 4.9 volts and averaging about 4.8 volts.

CONCLUSIONS

1. A-section performance at 24 months was low and the number of failures high. This large drop in performance is attributed to the continued dissolution of zinc on shelf, making the zinc anode limiting to performance. Excessive zinc dissolution was caused by local action around the solder joint, and by external shorting through leakage electrolyte on the outside of the stack.

2. B-section performance at 24 months averaged 4-7 hours (omitting failures) at both -20° F. and -40° F. In the case of -20° F performance, which at 12 months gave about 14 hours, the decrease in performance between 12 and 24 months is attributed to an increasingly greater number of cells undergoing leakage during storage and corrosion of intercell contacts (aluminum foil and zinc tabs.) Performance (omitting failures) at -40° F. did not appear to be markedly reduced from that at 12 months; however, the number of failures increased.

3. C-section performance continued satisfactory.

4. Less failures were encountered under 35° F. storage than at 70° F. storage.

PROGRAM FOR NEXT INTERIM

All tests under this contract are now completed. A final report will be prepared as scheduled.

IDENTIFICATION OF KEY PERSONNEL

Mr. Philip F. Albert, Manager Government Research Contracts

Mr. Albert received his B.S. degree in Chemical Engineering from the University of Wisconsin in 1943. He has been engaged in battery research and development activities with the Ray-O-Vac Company for the past 15 years.

Mr. John W. Paulson, Research Engineer

Mr. Paulson received his B.S. degree in Chemical Engineering from the University of Wisconsin in 1951. He has been engaged in battery research and development activities with the Ray-O-Vac Company for the past 9½ years.

TABLE I

Specifications

	Section A	Section B_1	Section B_2
Mix weight/cell, gm.	12.5-13.5	7.0-8.0	4.5-5.0
Minimum OCV at 14 days after construction:			
LiCl:CP-2	1.65	49	49
LiBr:CP-2	1.60	48	48
Minimum flash amperage at 14 days after construction:			
LiCl and LiBr	25	1.0	1.0

Electrolyte Composition:

Lithium Chloride	Lithium Bromide
15.0% LiCl	22.7% LiBr
12.0% $ZnCl_2$	13.6% $ZnBr_2$
8.0% NH_4Cl	9.1% NH_4Cl
65.0% H_2O	54.6% H_2O

TABLE II

BA-2270/U In-Plant Test Results
LiCl:CP-2 System

Performance, Hours

Test Temperature:	70°F				-20°F				-40°F			
	Code	A	B_1	B_2	Code	A	B_1	B_2	Code	A	B_1	B_2
24 mos., 35°F Storage	03260	0	53.20	56.55	03260	0	5.84	6.67	03260	0	4.33	4.67
Individual values	"	0	53.20	8.02	"	0	5.56	2.33	"	4.84	4.00	4.00
	"	0.59	73.67	0	"	0	5.00	5.20	"	0.84	4.00	3.18
	"	1.00	51.50	56.17	"	0	7.33	7.00	"	4.33	5.33	4.00
	"	0	46.67	53.95	"	0.67	7.07	0	"	4.00	5.89	0
	04160	0	52.00	0	04160	0.84	4.60	3.79	04160	0	0.73	0.20
	"	0.28	0	24.49	"	0	4.00	3.67	"	0	3.67	3.67
	"	0	53.60	3.20	"	0.84	4.33	3.67	"	0	3.92	0
	"	0.68	54.00	56.25	"	1.50	7.00	0.06	"	0	1.27	0
	"	0	48.00	60.00	"	6.00	6.00	4.44	"	0.33	3.67	3.67
					"	0	3.81	4.50	"	1.00	0	0
					"	2.67	3.81	2.33	"	0	0.52	0
	"				"	2.67	3.67	0	"	0	1.67	0
					"	0.13	3.33	0	"	0	4.33	0
					"	0.04	4.50	0	"	0	4.00	0.12
Average		0.26	48.58	31.86		1.02	5.10	2.91		1.02	3.16	1.57
Total No.		10	10	10		15	15	15		15	15	15
No. Failures		9	1	2		11	0	5		11	3	9
Average, omitting failures		1.00	53.98	39.82		3.21	5.10	4.36		3.54	3.84	3.86
% of Initial Perf. (0 Mos.), omitting failures		1.7	137.0	84.7		25.4	38.2	31.3		57.2	55.5	54.5

TABLE II (Cont'd)

Test Temperature	70°F				-20°F				-40°F			
	Code	A	B_1	B_2	Code	A	B_1	B_2	Code	A	B_1	B_2
24 mos., 70°F storage	03260	7.33	48.00	51.67	03260	0	8.00	8.89	03260	3.22	0.01	0.04
Individual values	"	0	51.00	0	"	0.50	0	0.08	"	1.17	0	0
	"	0	46.86	34.32	"	2.67	8.59	0	"	2.56	0	0
	"	30.00	0	0.21	"	0.06	6.67	5.67	"	4.00	5.00	6.17
	"	27.00	40.62	0.24	"	1.00	7.67	0.06	"	1.50	4.67	6.17
	"	12.00	0	0	04160	1.00	0.46	0	04160	0.56	0	0
	"	0	53.00	56.00	"	3.00	0	0	"	0	0	0
	"	0	69.54	0	"	1.17	0	0	"	0.89	0.08	0.17
	"	14.00	50.00	56.22	"	0	5.33	5.51	"	0	3.78	3.75
	"	0	73.50	0	"	4.33	5.33	5.52	"	0	11.67	0
					"	5.67	4.44	0	"	0	8.00	0
					"	5.67	6.00	0	"	2.67	9.34	0
					"	3.00	6.33	6.56	"	0	0	0
					"	3.67	6.67	3.33	"	0	0	0
					"	5.67	0	0	"	0	0	0
Average		9.03	43.25	19.87		2.49	4.37	2.37		1.10	2.84	1.09
Total No.		10	10	10		15	15	15		15	15	15
No. Failures		5	2	6		4	5	9		9	9	12
Average, omitting failures		18.06	54.06	49.55		3.10	6.50	5.91		2.52	7.08	5.36
% of Initial Perf. (0 Mos.) omitting failures		30.6	137.2	105.5		24.6	48.7	42.4		40.7	102.0	75.6